Air Force Global Horizons

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Chief Scientist

24 April 2013

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Global Horizons

Terms of Reference

- **Background:**
  - **Global demographic, economic, technological, and military trends forecast an increasingly complex, competitive, and contested future.**
  - **Need an Air Force wide, collaboratively derived, near-, medium- and far-term S&T vision that articulates revolutionary capabilities that anticipate future threats, mitigate vulnerabilities, and shape and take maximal advantage of impending and unexpected opportunities to sustain our strategic advantage and assure Global Vigilance, Global Reach and Global Power across air, space, and cyberspace.**
- **Key Stakeholders:** **Air Staff, MAJCOMS, AFRL, Agencies, International**
- **Approach**
  - **Identify and forecast global trends (e.g., economic, demographic, S&T, military) and S&T revolutions that may radically transform threat vectors and/or opportunity spaces**
  - **Identify and prioritize the most promising S&T areas for dramatic change (economic, operational) in core AF missions**
  - **Articulate AF near (present-17), mid (FY18-22) and far (FY23-27) term S&T to fill gaps, indicating where AF should lead, follow, or watch**
  - **Prioritize the most strategic AF problems and identify best practices (e.g., partnerships, competitions, prizes) for motivating solutions that help overcome obstacles and achieve more rapid and economical S&T advancement**
  - **Engage and partner (industry, academia, national labs, FFRDC, government)**
- **Product:** **Global HorizonsS&T Vision to top 4 by ~~8/15/13~~ 5/7/13 (Report ~~10/1/13~~ 6/1/13)**

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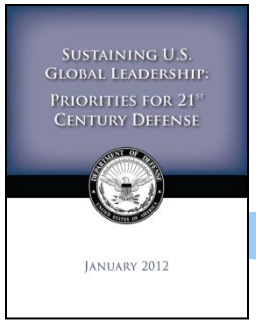
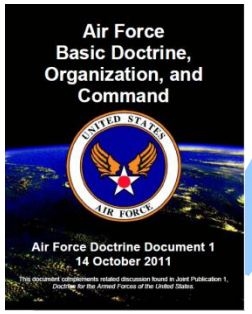
Global Horizons

Study Methodology

STRATEGY

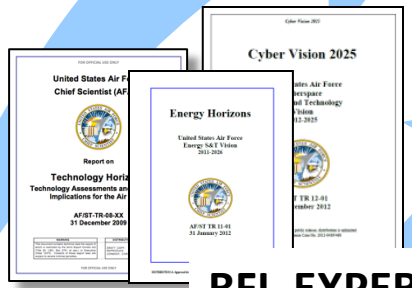




REQUIREMENTS AND PLANS

COCOM and MAJCOM Requirements

CFMPs, STIPLs



RFI, EXPERT SUMMITS

Global Horizons

United States Air Force Global S&T Vision 2013-2027

AF/ST TR 13-01
1 August 2013

Independent Senior Expert Review

Global Threats and Opportunities

MISSION FOCUS	GLOBAL SECTOR
Air	Transp
Space	Manuf
Cyber	Comm/IT
C2	Energy
ISR	Health
Support	Ed/Train

Enabling S&T

GLOBAL PRIVATE SECTORS

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Global Horizons Stakeholders

- **Senior Governance Team (3*) and Key Senior Stakeholders**

Air Staff
AF/CVA: Lt Gen Frank Gorenc
AF/A1: Lt Gen Darrell Jones
AF/A2: Lt Gen Larry James
AF/A3/5: Lt Gen Burton Field
AF/A4/7: Lt Gen Judith Fedder
AF/A8: Lt Gen Michael Moeller
AF/A9: Dr. Jacqueline Henningsen
AF/RE: Lt Gen James Jackson
AF/SG: Lt Gen Thomas Travis
AF/ST: Dr. Mark Maybury (chair)

Secretariat
SAF/GC: Mr. Charles Blanchard
SAF/FM: Ms. Marilyn Thomas
SAF/IE: Mr. Terry Yonkers & Ms. Kathleen Ferguson
SAF/CIO A6: Lt Gen Michael Basla
SAF/AQ: Lt Gen Charles Davis
SAF/IA: Ms. Heidi Grant
SAF/US(M): Mr. David Tillotson
SAF/PA: Brig Gen Les Kodlick

MAJCOM Representatives
ACC/CV: Lt Gen William Rew
AMC/CV: Lt Gen Robert Allardice
AFMC/CV: Lt Gen Andrew Busch
AETC/CV: Lt Gen Douglas Owens
USAFE/CV: Lt Gen Noel Jones
AFSPC/CV: Lt Gen John Hyten
PACAF/CV: Lt Gen Stanley Kresge
AFRC/CV: Maj Gen Craig Gourley
AFSOC/CV: Brig Gen Michael Kingsley
NGB/CF: Brig Gen James Witham
AFGSC/CV: Maj Gen Everett Thomas

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Global Horizons Leads

- **Core Function Teams**
  - **Threat: Mr. Gary O'Connell (NASIC), Maj Gen Jim Keffer (A2), Col Matthew Hurley (AF/A2DD)**
  - **Air: Dr. Don Erbschloe (AMC), Dr. Dave Robie (ACC), Doug Bowers (AFRL/RQ), Bill Harrison (AFRL/RQ), Dr. Bob Peterkin (AFRL/RD), Dr. Mikel Miller (AFRL/RW), Dr. Kamal Jabbour (AFRL/RI), Dr. Brian Kent (AFRL/RY)**
  - **Space: Dr. Doug Beason (AFSPC), Dr. Jim Riker (AFRL/RV), Col Scott Beidleman (SMC/XR), Dr. Roberta Ewart (SMC/XR), Dr Alan Weston (NASA)**
  - **Cyber: George Duchak/Dr. Rich Linderman (AFRL/RI), Dr. Doug Beason (AFSPC), Mr. Arthur Wachdorf (24AF), Frank Konieczny (SAF/A6 CTO), Mr. Mike Kretzer (688th), Steve Schneider (AFRL/RY), Dr. Rusty Baldwin (AFIT/ENGE)**
  - **C2 and ISR: Dr. Steven K. Rogers (AFRL/RY/RI), Dr. Terry Wilson (RY), Mr. Stan Newberry (AFC2IC), Dr. Chris Yeaw (AFGSC/ST), Jeff Eggers (AF/A2), Keith Hoffman (NASIC), Mr. Bill Marion (ACC)**
  - **Mission Support (Acquisition, T&E, Workforce): Dr. David Walker (AQR), Susan Thornton (AFMC/EN), Col Derek Abeyta (AF/TE), Maj Mike Dunlavy (SAF/AQR), Lt Col Dan Ward (LCMC), Ed Kraft (AEDC/CZ), Dr. Alok Das (RY)**
  - **Enabling Technology: Dr. Jennifer Ricklin (AFRL), Dr. Chuck Matson (AFRL/AFOSR/CL), Dr. Pat Carrick (AFRL/AFOSR/RT)**
- **Global Sector Teams**
  - **Manufacturing and Materials – Dr. Barry Farmer (AFRL/RX), Doug Bowers (AFRL/RQ), Dr. Mikel Miller (AFRL/RW), Col Keith Bearden (AFLCMC/XZ), Rollie Dutton (AFRL/RXM)**
  - **Transportation and Logistics – Don Erbschloe (AMC), Steven Hofmann (A3O, Next Gen)**
  - **Energy, Utilities & Mining – Dr. Kevin Geiss (SAF/IE), Bill Harrison (AFRL/RZ), Bob Peterkin (AFRL/RD)**
  - **Health Care & Pharma – Dr. Morley Stone (AFRL/RH), Deb Niemeyer (59 MDW/ST), Lt Gen Tom Travis (AF/SG); Col Randy Ashmore (AFMSA/SG5)**
  - **Communications, Information Technology, Financial Services - George Duchak/Dr. Rich Linderman (AFRL/RI), Dr. Doug Beason (AFSPC), Dr. Kamal Jabbour (AFRL/RI), Dr. Paul Antonik (AFRL/RI), Dr. Rob Gold (ASD R&E)**
  - **Education and Training – Dr. Bruce Murphy (AU/VP Academic Affairs), Dr. Todd Stewart (AFIT), Dr. Nathaniel Davis (AFIT), Jack Blackhurst/Dr. Morley Stone (AFRL/RH), John Geis (AU/AFRI), Dr. Steven Hansen (AU), BGen Scott Vander Hamm/Craig Seeber (AETC/A5/8/9A), Lt Col Chris Bohn (AETC/Spaatz Center), Dr. Aaron Byerley, (USAFA)**

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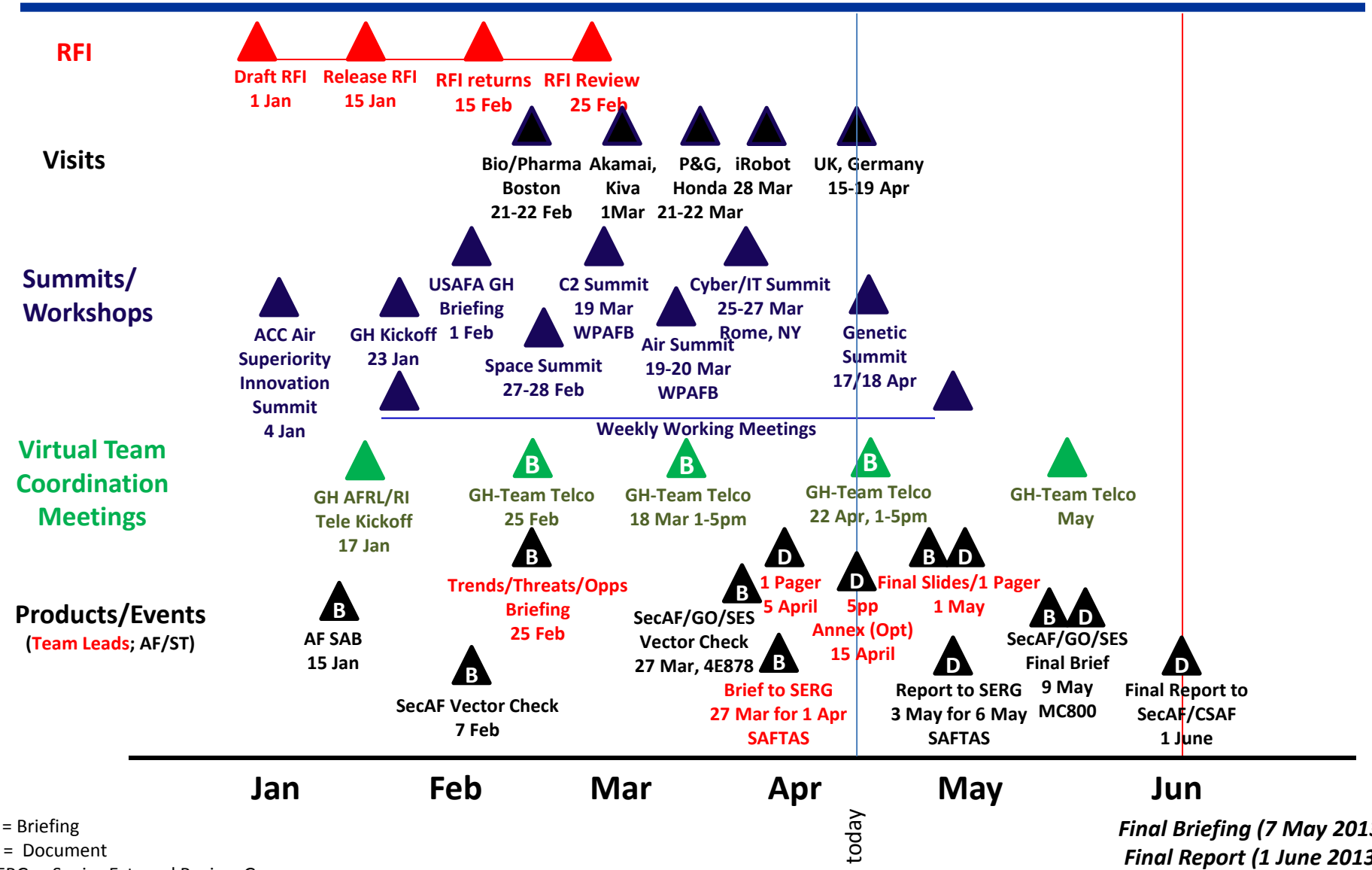
Senior Independent Expert Review Group (SIERG)

Air	Space	Cyber	C2ISR	Msn Support	S&T, Threat, …
Trans	**Man/Mat**	**Comm/IT/FInancial**	**Energy**	**Ed & Train**	**Health**
Dr. Mark Lewis, IDA	*Dr. Mike Yarymovych, Sarasota Space*	Prof Ed Feigenbaum, Stanford Gil Vega, DoE Andrew Makridis, CIA Glenn Gafney, CIA	Prof. Alex Levis, GMU Dr. Donna Rhodes, MIT SEAri Dr. Mica Endsley, SATech	Dr. Steve Walker, DARPA Norm Augustine Heidi Shyu, ASA ALT Mr. John Gilligan	Gen (Ret) Mike Carns Prof. Werner Dahm, ASU Lee Jameson, NSF Charles Bouldin, NSF Lauren M. Van Wazer, OSTP Tomas Vagoun, NITRD
Natalie Crawford, RAND	*Dr. Rami Razouk, Aerospace*	Dr. Paul Nielsen, CMU/SEI Dr. Steve Burssolari, MIT LL Alan Bernard, MIT LL	Al Grasso, MITRE Ralph Semmel, JHU-APL	Jim Gosler, Sandia Giorgio Bertoli, Army	Konrad Vesey, IARPA Stan Chincheck, NRL Dr. Walter Jones, ONR
Lt Gen (Ret) George Muellner	*Dr. Eli Neiwood, MIT LL* *Dr. David Miller, MIT* Don Kerr Keith Hall	Gen Mike Hayden (Ret), USAF Lt Gen Ken Minihan (Ret) USAF Paul Laugesen, NSA/TAO Dr. Yul Williams, NSA/CSS TOC Dr. Mike Wertheimer, DoD Dr. Boyd Livingston, DoD Lt Col Marion Grant, USCYBERCOM/J9	VADM (Ret) Mike McConnell Lt Gen (Ret) David Deptula Dr. Jim Hendler, RPI Ray Haller, MITRE Dr. Steve Cross, GTRI Landon Derentz, DoE	Al Shaffer, OSD (R&E) Greg Smith, NGA Ben Steinberg, DoE Gen (Ret) Duncan McNabb	Gen (Ret) Jim McCarthy, USAFA Dr. Peter Friedland Prof Pat Winston, MIT Terry Jaggers, NAS Richard Matlock, MDA
Robert Osborne, NNSA Dr. Tom Hussey, AFOSR	Dr. Mason Peck, NASA CTO BGen (Ret) Pete Worden, NASA Matt Linton, NASA ARC-IS	Dr Starnes Walker, Navy Larry Schuette, ONR Tim Grance, NIST Dr. Steven King, OSD(R&E) PSC	Lt Gen (Ret) Ted Bowlds Lt Gen (Ret) Robert Elder MGen (Ret) Ken Israel	Dr. Tim Persons, GAO Brian Hughes, AT&L Tom Ehrhard, OSD(P)	David Honey, DNI Dr. Kathryn Sullivan, NOAH Paul Kaminski, DSB Chair
Former USAF Chief Scientist	Former NRO Director	Former Director NSA, DIA	Former DNI	Former CSAF or VCSAF	*AF SAB EXCOM*

Coalition

AVM Brecht & Mr. Philip Rayfield, MoD UK Dr. Anthony Shellhase. DSTO, Australia Mr. Christopher McMillan, DRDC Canada

Global Horizons (GH) Schedule



B = Briefing
D = Document
SERG = Senior External Review Group

Final Briefing (7 May 2013)
Final Report (1 June 2013)

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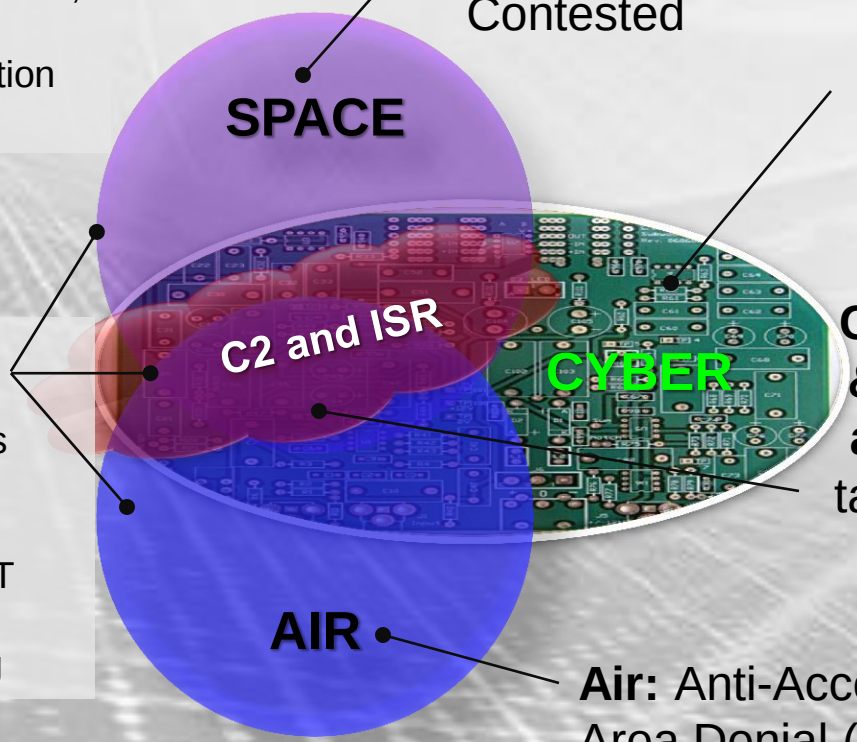
Global Environment

Global Forces

- Demographics
- Climate
- Resources (Natural, Talent, Treasure, Time)
- Globalization/Proliferation
- Conflict

Space: Congested, Competitive, Contested

Cyberspace: threatened by malicious insiders, supply chain attacks, and advanced persistent threats to deceive, degrade, disrupt, destroy



Global Sectors

- Manufacturing and Materials
- Transport and Logistics
- Energy and Utilities
- Health and Pharma
- Communications and IT
- Financial Services
- Education and Training

Command and Control (C2) & Intelligence Surveillance and Reconnaissance (ISR) targeted as a center of gravity threatening integrated and resilient global operations

Air: Anti-Access, Area Denial (A2/AD)

Global Vigilance, Reach and Power dependent upon contested Global Commons and Globalized Industrial Sectors

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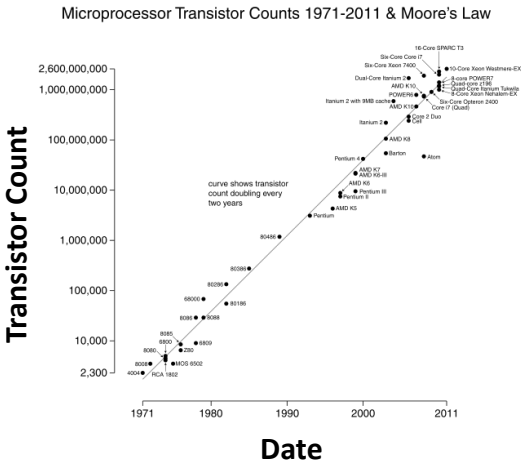
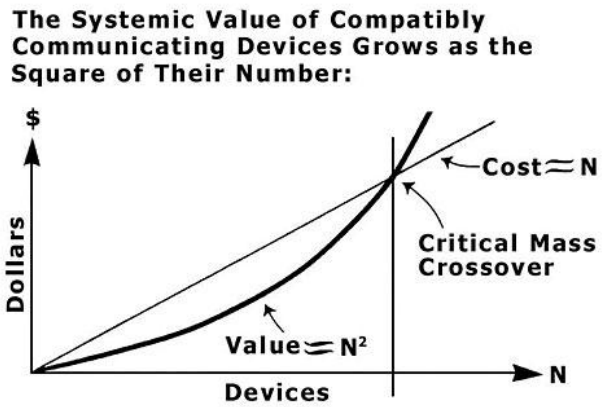
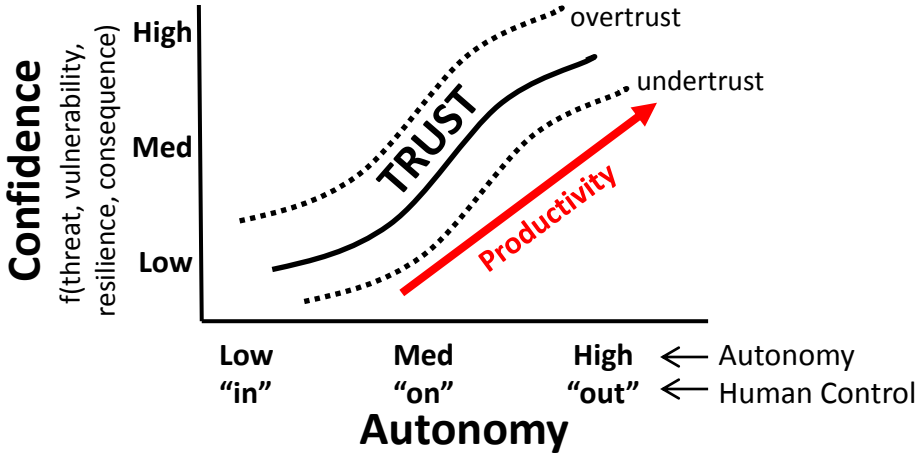
Laws Help Forecast Future



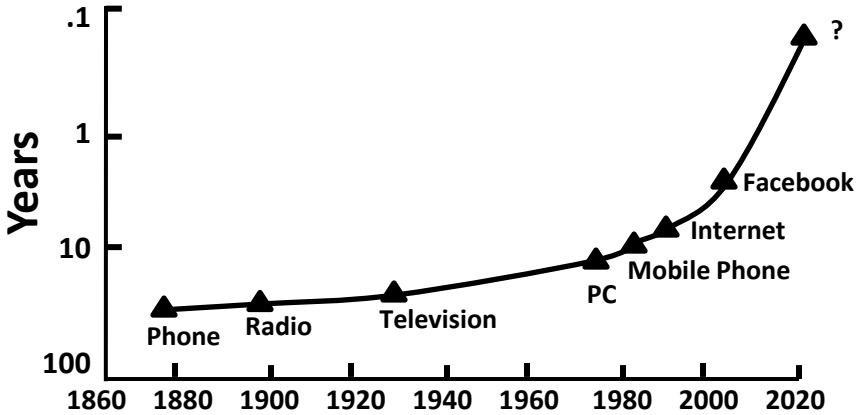
Moore's Law



Metcalf's Law



Maybury's Law

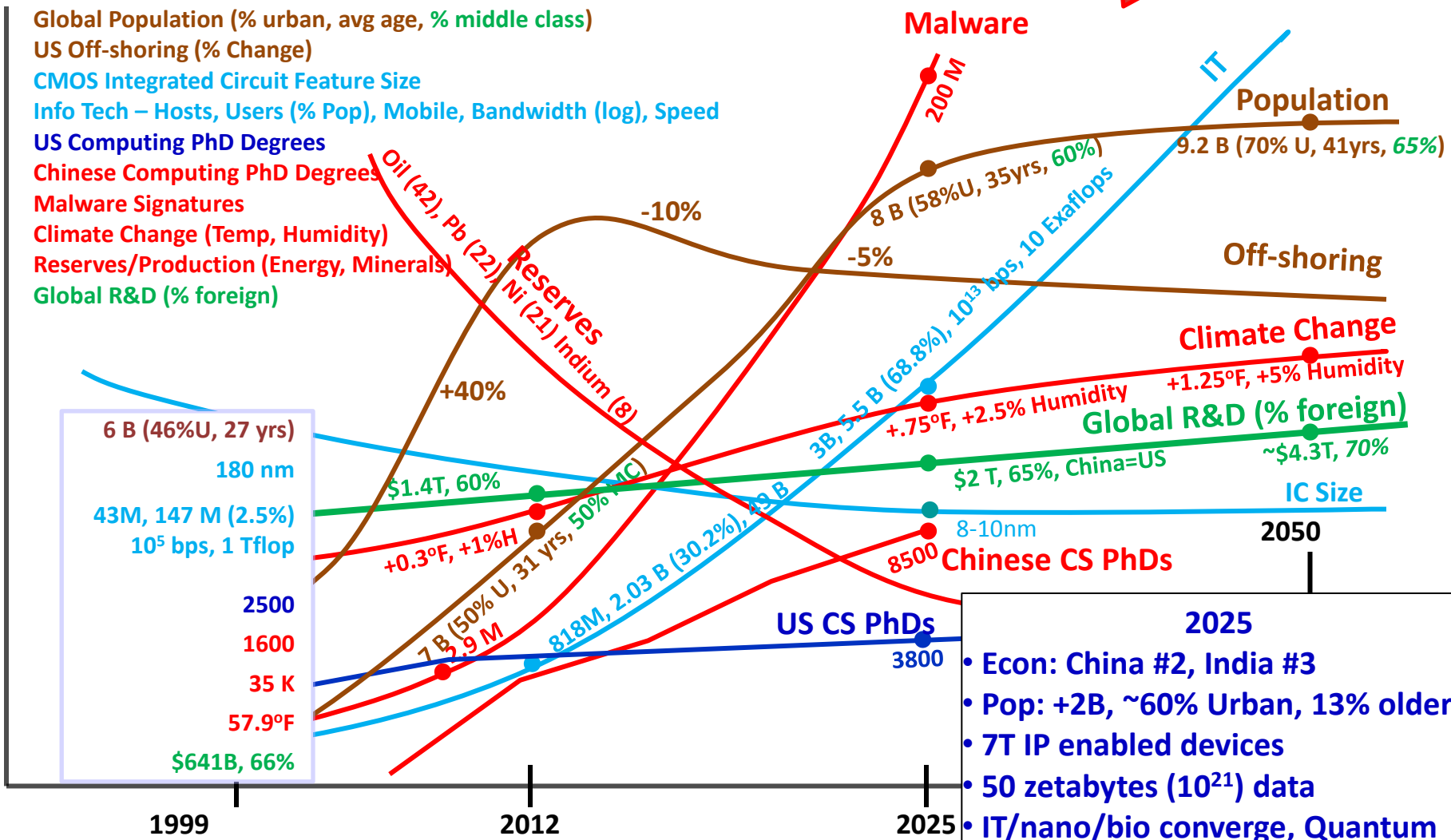


Adoption Acceleration

Source: KurweilAI.net

Global Horizons

1999-2025+



2025

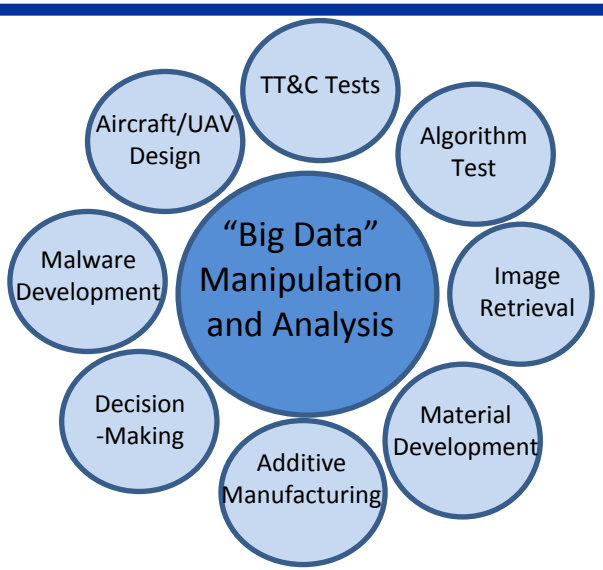
- Econ: China #2, India #3
- Pop: +2B, ~60% Urban, 13% older
- 7T IP enabled devices
- 50 zetabytes (10^{21}) data
- IT/nano/bio converge, Quantum
- Climate Extremes, Scarecity
- World Bank, WTO, IMF

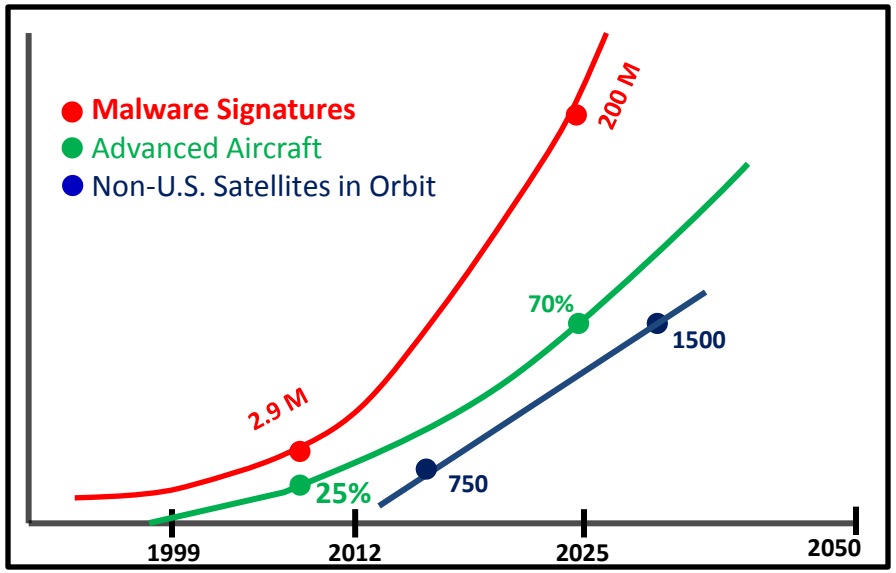
CMOS – Complimentary Metal-Oxide Semiconductor; IC – Integrated Circuit
World Trade Organization (WTO), International Monetary Fund (IMF)
PhD Degrees in Computer Science/Computer Engineering/Computational Mathematics

ution is unlimited. Public Rele

Threat Development

- **S&T talent drive air/space/cyber research and development**
  - **By 2015, Brazil, China, and India will graduate 88% of worldwide graduates in STEM programs accelerating solutions to militarily significant technology problems ***
- **"Big Data" enables accurate and innovative analysis**
  - **40 Zetabytes by 2020 (1.8 ZB in 2011)**
- **Increased pace of technology development**





* No Shortage of Talent. September 2011
Accenture Institute for High Performance Analysis,

TT&C = Telemetry, Tracking & Command

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Trend-Threat-Capability

DRAFT

Global Trend	Military Threat/Requirement	Required Capability
Proliferation - Missile - Jam/Spoof	Medium and Long range Missiles, Counter EW, Counter DE	-BMD (all domains), Hypersonics -Assured Comms -PNT
Youth Growth (Middle East/Africa)	Growth of Islamic Fundamentalism	COIN, Ubiquitous ISR, Human terrain
Urbanization	Insurgent Operations	Persistent ISR, Precision Strike for Zero Collateral Damage, Urban Operations, Agile Mobility
Global Climate Change	Sea Level Rise, Desertification, Change in geographic focus, challenges to allies' sovereign territories	Expeditionary operations, Mobile basing, Global mobility, Humanitarian Operations
Resource Depletion	Natural Resource Conflict	Alternative/Sustainable Energy, New Materials, Recycling of Rare Materials
Growing Deficits	RDT&E Restrictions	Low Cost, Innovation, Sustainable Weapon Systems
Declining STEM	Technology gaps with peer/near-peer	Virtualized education & training

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Function to Sector Mapping

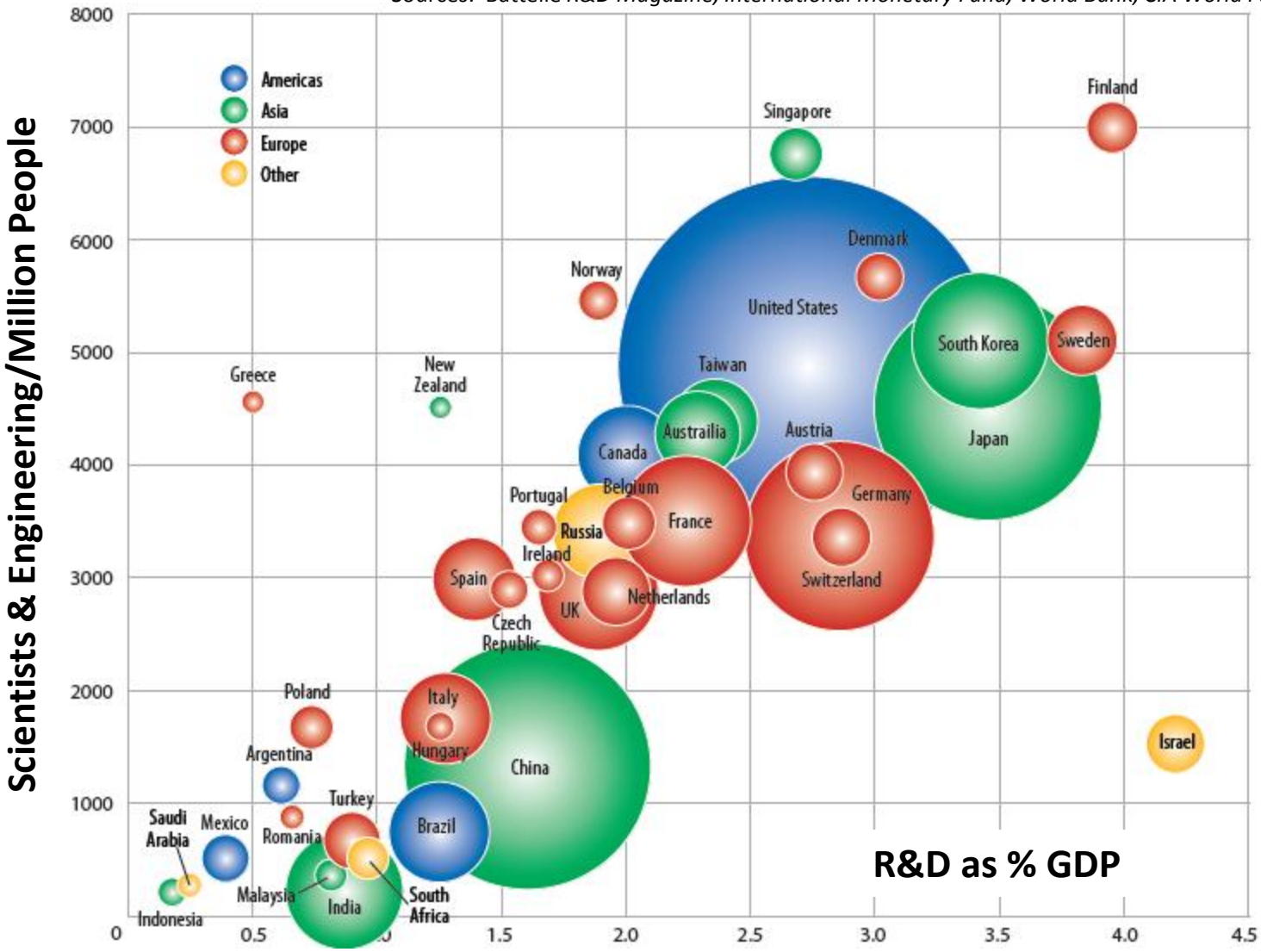
FUNCTION/ SECTOR	Threat	Air	Space	Cyber	C2	ISR	Support
Threat		Missiles, DE	Direct Ascent	Supply Chain, Insider, APT	D4, Integrity	D4, Integrity	Supply, Life Cycle
Manuf & Materials	Global S&T Intelligence, Nano sensors	Autonomy, Robots, Add Manufact., Composites, Nanotech, Design	Autonomy, Robots, Add Manufact., Nanotech, Design, Manuf in Space	Autonomy, Robots, Nanotech, Design, Rev Engineering	Autonomy, Robots, Nanotech, Design	Autonomy, Robots, Add Manufact., Composites, Nanotech, Design	Add Manufacturing
Transport & Logistics	Smuggling, Trafficking	Autonomy, scheduling, tracking, energy	Autonomy, tracking, launch, space transport	Global Supply/ Logistics	Global Supply/ Logistics	Global Supply/ Logistics	Global Supply/ Logistics
Health & Pharma	Illegal drug trade, unregulated manufacture	Perform enhance, bio, force protect	Perform enhance, bio, force protect	Perform enhance, bio, force protect	Perform enhance, bio, force protect	Perform enhance, bio, force protect	Trauma, supply chain protection
Energy, Util, Mining	HPM and Lasers, Rare materials	Bio Fuels, Directed Energy	Directed Energy, Space Mining	SmartGrid	SmartGrid	Bio Fuels, SmartGrid	Gas/Oil, (Small Modular) Nuclear, Sunshine to Petrol
Comm, IT	Hacking, Decryption	Artificial cortex, quantum, intelligent spectrum, wireless ubiquity, laser com, PNT					
Financial	Global Debt, Terrorist Financing	Automation, InfoSec (Key Management, Insider Threat), Privilege Management, Offshoring					
Ed & Train	Terrorist training	Virtual gaming, Intelligent Tutoring, Augmented Cognition					

DRAFT

Global R&D (2011)

Size of circle is relative amount of Annual R&D

Sources: Battelle *R&D Magazine, International Monetary Fund, World Bank, CIA World Factbook, OECD*



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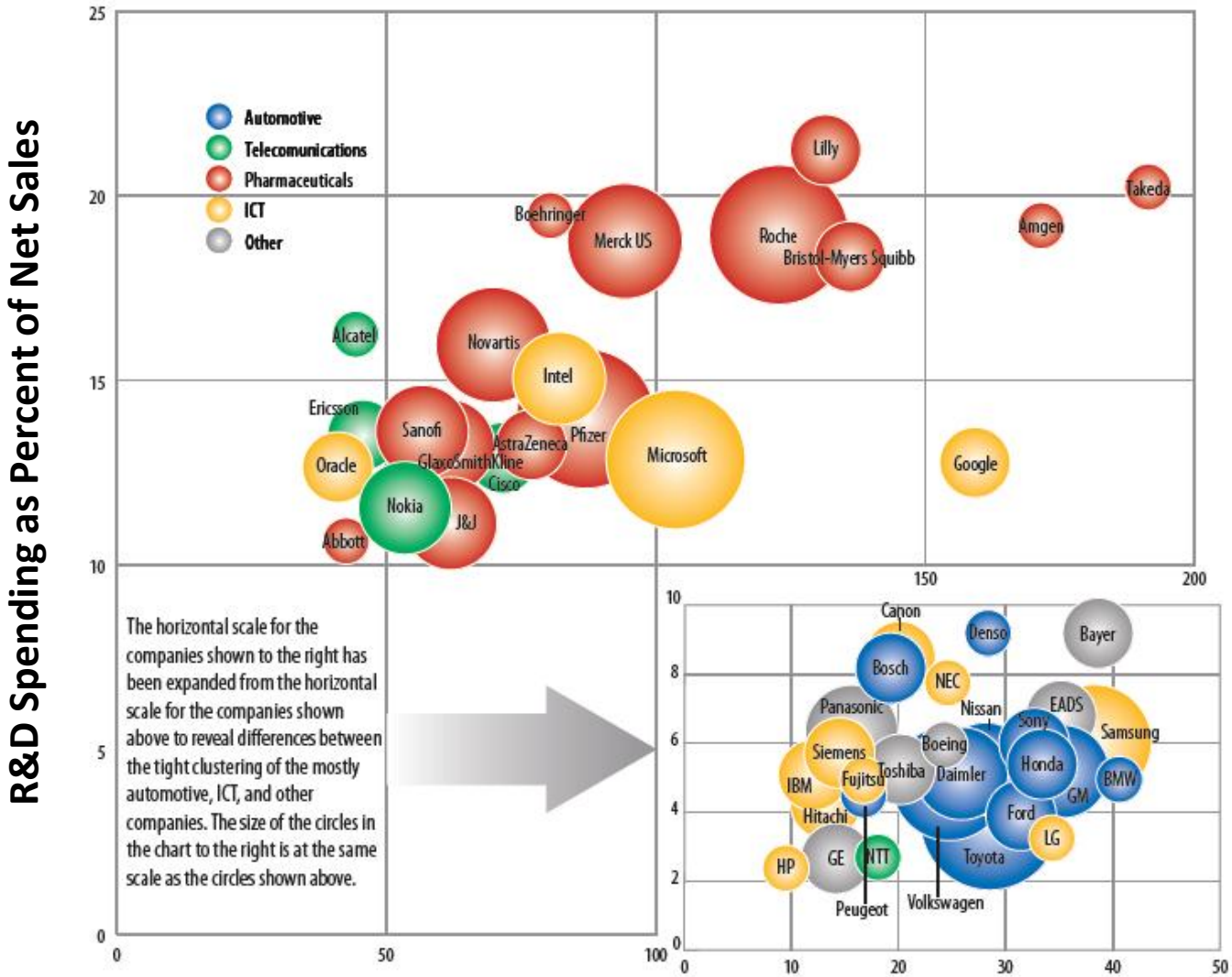
Industrial R&D (2010)

Size of circle is relative amount of Annual R&D

Source: Battelle R&D Magazine



RFI: tinyurl.com/GlobalHorizonsRFI
Completed: 15 Feb 2013

Concept Quad for Global Horizons RFI

(examples FICTITOUS)

FUNCTION: (air, space, cyber, C2, ISR, msn support)
SECTOR: (eg., man., log., fin.)
TRL: 1-9
MRL: 1-10
CLASSIFICATION

Objective (relate to Global Horizons Needs)

- **Clearly state the problem and why it is hard**
- **State qualitative & quantitative objectives, e.g.,**
  - **Revolutionary new technology to decrease maintenance cost by five fold**
  - **50% increase in mean time between failure, 100% increase in part failure prediction accuracy, 25% increase in reuse**
- **Relate objectives to AF function (air, space, cyber, C2, ISR, mission support), global threat, and global opportunity (e.g., robustness, resiliency, stealth, efficiency)**

Revolutionary Concept/Capability

- **What specific new material, operational, and/or cultural change will result from activity and when?**
- **How does what you propose differ from today?**
- **What is revolutionary/game changing about your idea?**

• Include graphic as appropriate
• Attach any existing studies/analyses/papers

Technical Approach

- **Detail of how you are going to achieve revolutionary technological breakthrough. (What are the mid term and final exams?)**
- **What kind of exploration, experimentation, and/or demonstration is required? How long?**
- **Why will it be successful? Provide explicit evidence (past/current experiments, pilots, preliminary results) that illustrate feasibility**

Risk and Impact/Payoff

- **Identify the top risks (technical, transition, operations, economic, etc.) and TRL, MRL**
- **Project cost/benefits as appropriate, e.g.**
  - **Cost: e.g., system or operational improvement, total life cycle or FDIP savings, and/or staff/fleet/facility impact**
  - **Benefits: e.g., $XM in savings, Y% reduced errors, Z% increased speed, etc.**

Additional detail, references etc. can be added as text in the notes section of this slide in no less than 10 pt font that describes/amplifies concept & addresses Heilmeier questions (see www.design.caltech.edu/erik/Misc/Heilmeier_Questions.html).

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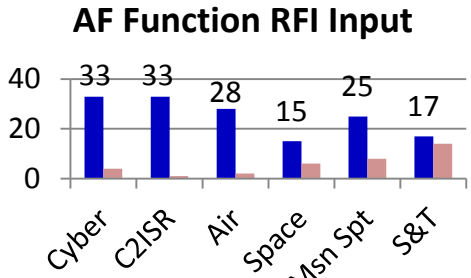
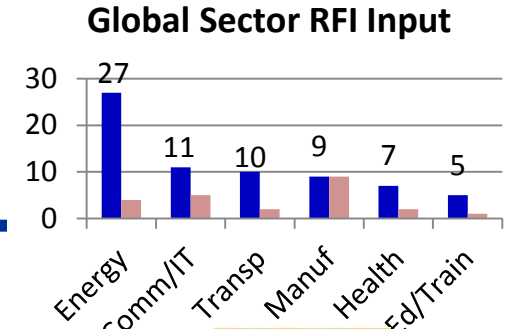
External Experience





Palantir
ROCKET LAB LTD
Innovative access to space
verizon
IBM
TERADATA
mc10
reshaping electronics
UNIVERSAL SPACE NETWORK
SSC
ITT EXELIS
SSLC
PUMPKIN
SPACE SYSTEMS
HONDA
McAfee
An Intel Compar
citibank
Sandia National Laboratories
BROOKHAVEN NATIONAL LABORATORY
home
Pacific Northwest NATIONAL LABORATORY
Los Alamos NATIONAL LABORATORY
EST. 1943
INL
Idaho National Laboratory
Lawrence Livermore National Laboratory
SPACE SYSTEMS LORAL
LOCKHEED MARTIN
NORTHROP GRUMMAN
Raytheon
UNION PACIFIC
Booz | Allen | Hamilton
Aurora
FLIGHT SCIENCES
ATK
United Technologies Research Center
HARRIS
BOEING
MGH 1811
MASSACHUSETTS GENERAL HOSPI
THE NEUROSCIENCES INSTITUTE
Innoflight
ALLEN INSTITUTE for BRAIN SCIENCE
Fueling Discovery
Virgin Galactic
Space Dynamics
AEROSPACE CONCEPTS
DEEP SPRINGS TECHNOLOGY
PRATT & WHITNEY
TRIDENT
Microcosm Inc
prime
DESIGNinteractive
goldbot
consulting
iRobot
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IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
JMG technology
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UNIVERSITY AT ALBANY State University of New York
USC
UNIVERSITY OF Cincinnati
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DARPA
UNM

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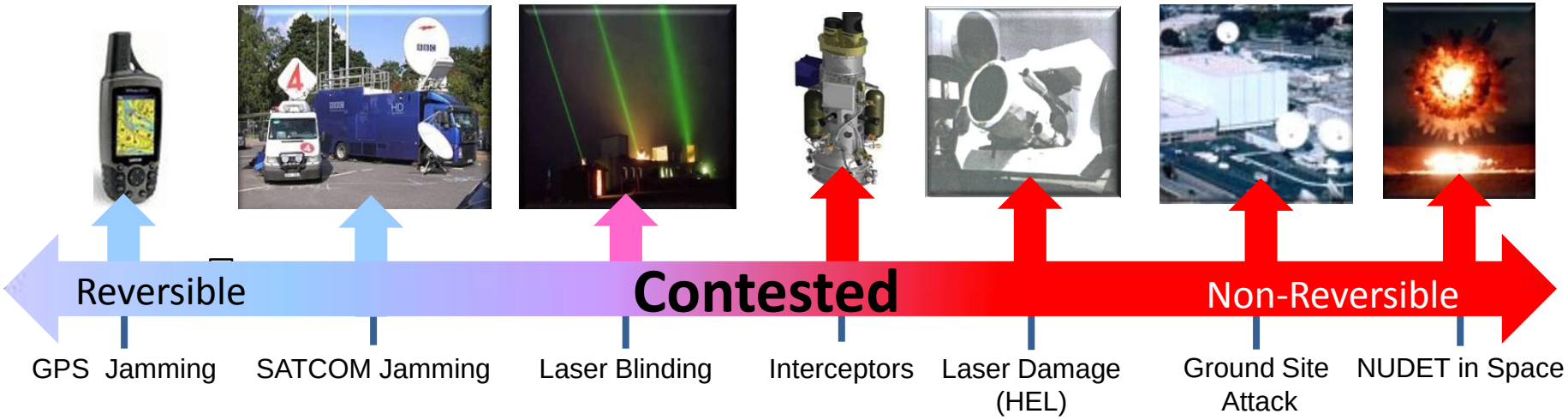
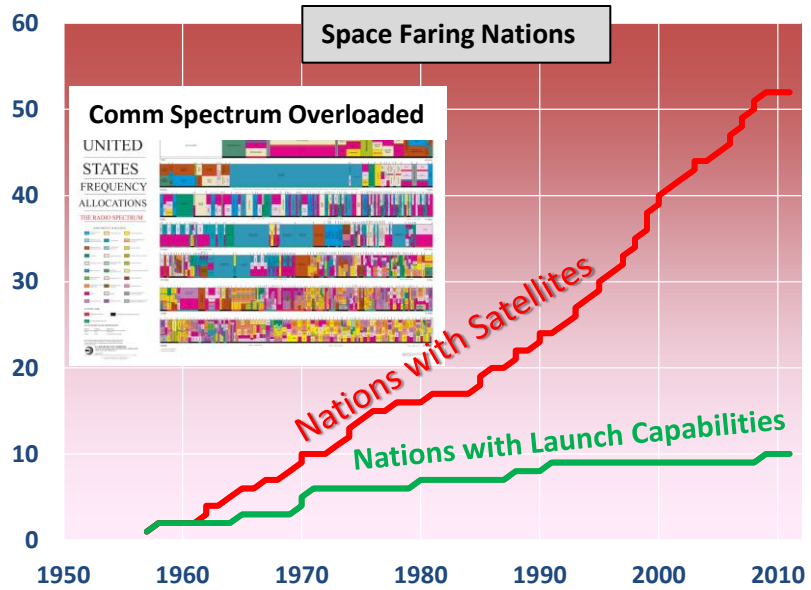
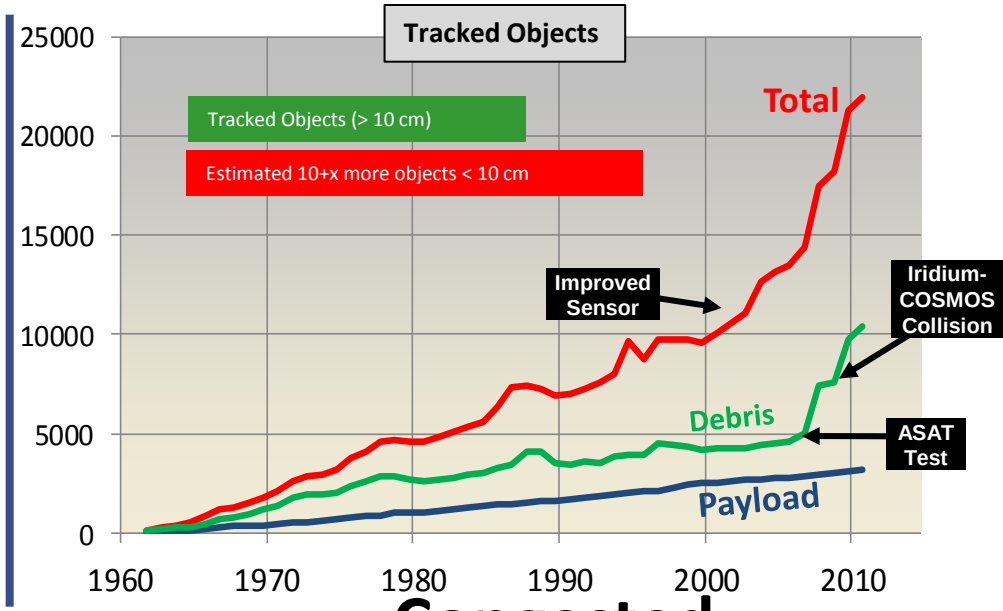
Space Trends/Challenges





Competitive



Congested

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Space S&T Game Changers/Roadmap

Technology	Near-term (FY13-17)	Mid-term (FY18-22)	Far-term (>FY22)
Disaggregation	F6 program (W)	NavSat (L)	Microsatellites (F)
Responsive Launch	100-kg to LEO for $1-3M (W)	GEO and LEO commodity launch (L)	Launch raw materials (L?), Launch deployables (L)
Space Cyber	Testbeds (L)	Space-HAIPE (F)	Agile and Resilient by Design (W)
Architectures	Deployable antennas (L), Open Standards (L)	Synthetic apertures (F) Open Arch (L)	Composable constellations (L)
Communications	AEHF (L) V/W band (L)	Laser Communications (F)	QKD free space, multiple site (F)
Manufacturing	Radiation-hard (L)	Additive Manufacturing (F)	Build in space (L?)

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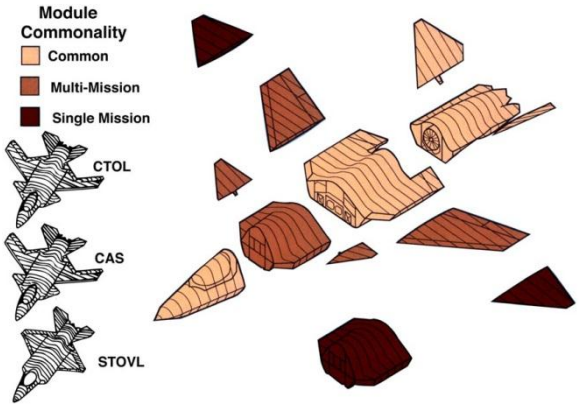
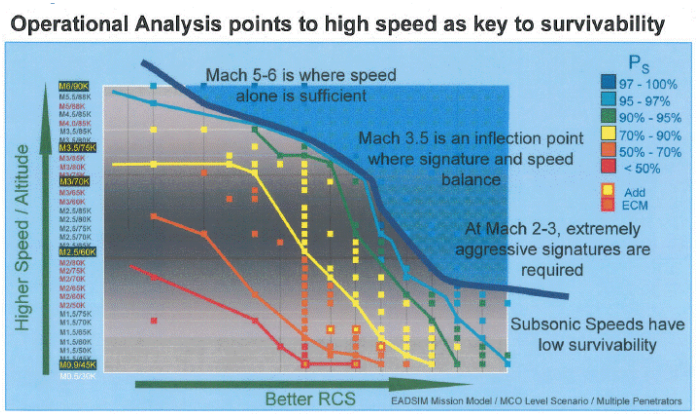
Air Game Changers

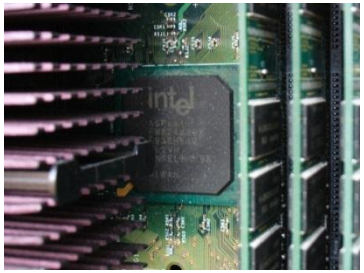


Modularity: "Plug and Play" armaments, avionics, airframe, mission

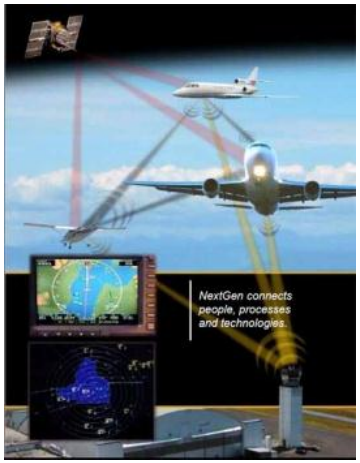
Autonomy: Bioinspired and Swarming

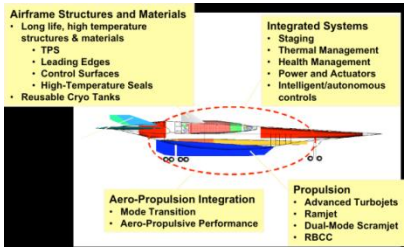


Speed: Gamechanger that requires synthesis of several technologies



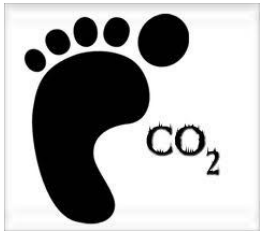
Distributed Decision Making: Requires gains in computing power, connectivity, and trust in systems & components





www.youtube.com/watch?v=Cu6E4mtO85I

Turning mandates into capability: Fuel efficiency to range, payload, endurance; avionics equipage to better SA; etc.



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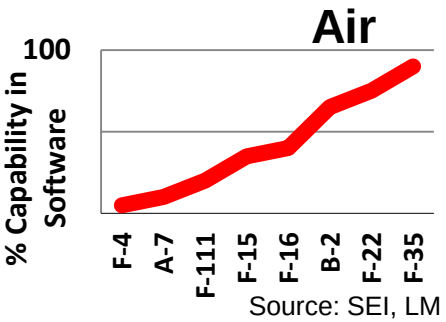
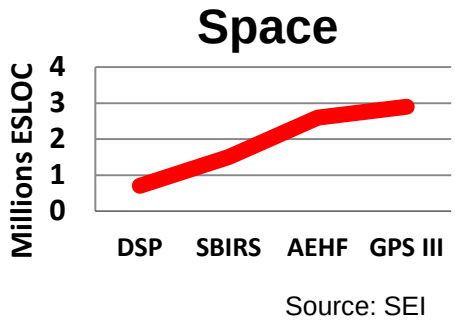
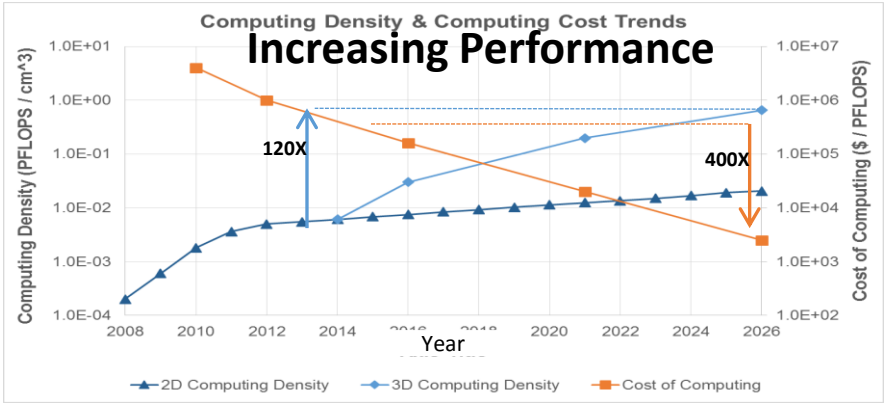
Cyber, Communications, IT, Finance Game Changers and Roadmap

Increasing Complexity







Area	Near (2013-2017)	Mid (2018-2022)	Far (2023-2027)
Cyber	Mission aware information objects (L)	Mission Aware Cyber C2 (L)	Autonomous Cyber Collectives (L)
	Quantum Encryption (W)	Real-time Cyber SA (L)	Dynamic S/W (F)
	Root of trust H/W & S/W (F)	Trusted embedded systems (L) Wireless Power (W)	Trusted Automation (F)
Communications	Cognitive Comms (L) Near-Field Communication (W)	Distributed & De-centralized Connectivity (L) Merged Communications, EW, SIGINT (L)	Quantum Communications (F)
Information Technology	Computational Intelligence (F) Deep Belief Networks (L)	Artificial General Intelligence (F) Large-Scale Inference (L)	Human-Level Autonomous Systems (F) Neuromorphic architecture (L, F)
	3-D integrated circuits (F)	Memristive devices and circuits (F) Spin Torque Transfer Technology (F)	Graphene-based circuits (F)
	Widespread Robotics (W) Big data analytics(L, F)	Quantum Computing (F)	Augmented Reality (F) Nano tailored circuits (F)
Finance	Advantage from maneuverability & big data analytics (W)	Personal Identity Authentication & Management (W) Assured Operations(W)	

DRAM = Dynamic Random-Access Memory

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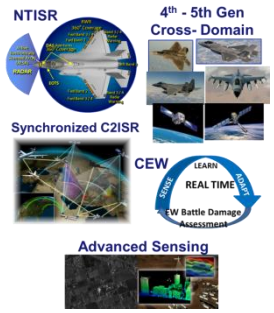
C2 and ISR
Game-Changers and Roadmap

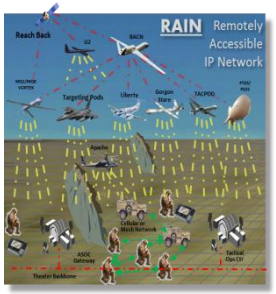
"Collect"

Integration across Missions and Domains



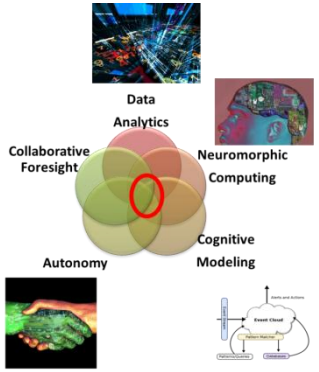
"Communicate"

Battlespace Networking for C4ISR Collaboration



"Process"

Innovative Exploitation



Game-Changer	Near (F13-FY17)	Mid (FY18-22)	Far (>FY23)
Integration across Missions and Domains	• ISR Enterprise Support for 5th Gen Air (F) • Distributed Team Collaboration for Integrated A/S/C Plans (W)	• Dynamic Reallocation of Resources (F) • Full spectrum targeting kinetic/non-kinetic (L)	• Automated Sensor Tasking (F) • Pervasive/Persistent C2ISR Enterprise (W)
Battlespace Networking for C4ISR Collaboration	▪ BLOS Integrated C2 to tactical edge (F) ▪ IFDL/MADL/Link16 gateway (L)	▪ Weapons Data Link (L) ▪ Rapidly Reconfigurable Systems (F)	▪ Fractionated/Distributed A/S/C intra-networks (L) ▪ Mission-aware routing and on-demand information prioritization & dissemination (F)
Innovative Exploitation	• Operational/adaptive machine learning with low power hardware (L) • Big data analytics (F)	• Integration of human sensing with machine intelligence for effective, trustable teaming (F) • Predictive cognitive modeling for system design and training Analysis of Alternatives (L)	• Cognitively enhanced complex event processing for novel autonomous system functionalities (W)

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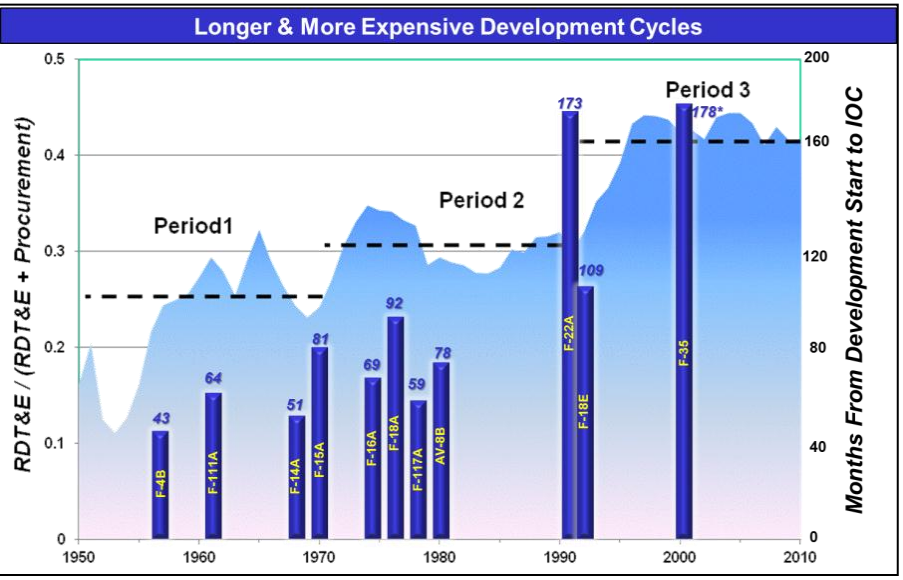
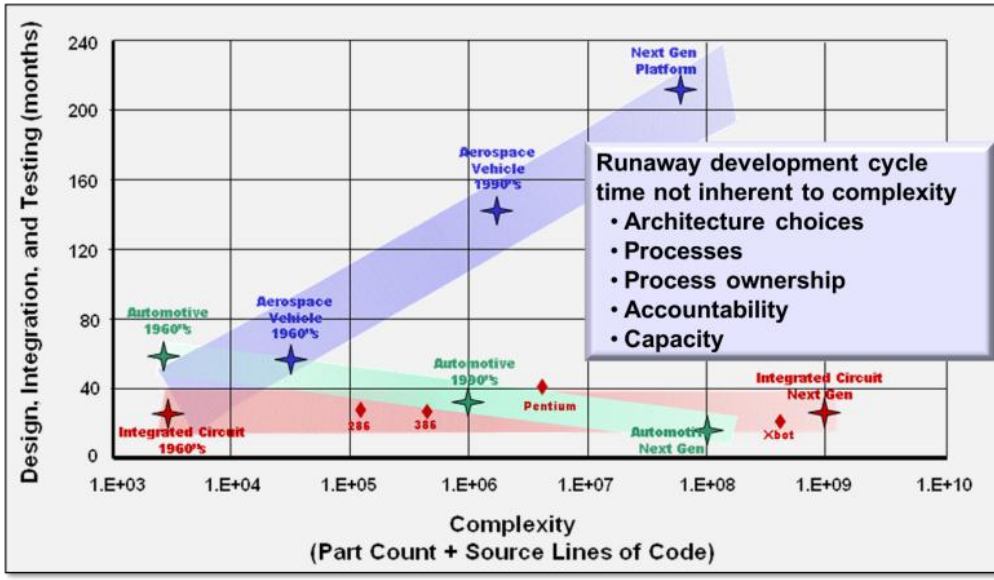
Mission Support

Trends (Acquisitions, T&E, Workforce)

- **Rapid innovation and emergence of new technologies**
  - **Agile SW, HW, manufacturing – rapid prototyping, scalable systems, & smaller lot sizes**
  - **Low-cost innovation – autonomous transatlantic robot (5-7 undergrads, $25K, 10 weeks)**
- **Increasing complexity, cost, and time-to-field of Defense systems**
  - **Highly interoperable and interdependent systems – 24M LOC in F-35**
  - **RDT&E is 40% of acquisition budget; avg time to IOC for next-gen F-XX to exceed 200mos (260% increase)**
- **Increasing global competition for highly skilled and technical workforce**
  - **80% jobs will require tech skills next decade; over 1 million US job openings in STEM-fields by 2018 (BLS)**
  - **US ranks 27th in % of undergrad STEM degrees; foreign born US PhD engineering grads>US born (NRC)**

small rocket nozzle





Source: Dr. Kirstie L. Bellman, **Making DARPA META Goals Come True: How do we Revolutionize Verification and Validation for Complex Systems?** S5 2010, WPAFB, June 17, 2010

Mission Support Opportunities
(Acquisitions, T&E, Workforce)

- **Revolutionize acq system w/agile approach – quickly field simpler, scalable, small production lot systems**
  - **Digital modeling to accelerate cycle time – concept trades, design, test, manufacture**
  - **Loosely coupled systems w/ designed-in trust & flexibility: scalability & rapid tech refresh**
  - **Reduce oversight, regs, reqs – empower decision makers & create culture NOT risk averse**
- **Generate buzz & excitement w/ revolutionary S&T – increase demos & better communicate capabilities**
  - **Create rapid design / prototype environ – fast build-test-break iterative cycle to demo/trans S&T**
  - **Open Innovations / Challenges for S&T info, concept demos, urgent needs – fast & broad solution set**
  - **Harvest small business innovation – require primes to team w/small business– tie to award fee**
- **Attract, energize & retain best global talent: fund high value talent & ideas … not programs**
  - **Advocate for policy to grant Visas to world's best for DoD employment only**
  - **Place new S&E workforce in rapid prototype environment – create multi-disciplinary skills**
  - **Long-term view of S&E workforce – fund w/ 1 color of $, expand lab demo, & "ring fence" key talent**

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Education & Training

Virtualized Learning (Example: PME Teambuilding Exercise)

- **Increases exposure**
  - **Experiential activities available to wider audiences**
- **Increases precision**
  - **Simulations focus-able on specific needs and objectives**
- **Reduces cost**
  - **Eliminate need for travel**
- **Reduces physical risk/injury**
- **Improves participation**
- **Replayable scenarios**

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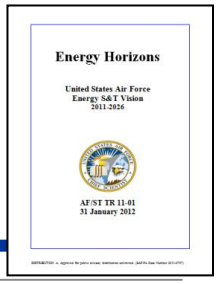
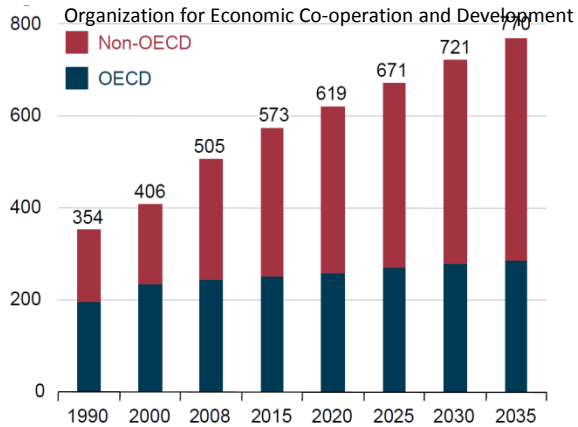
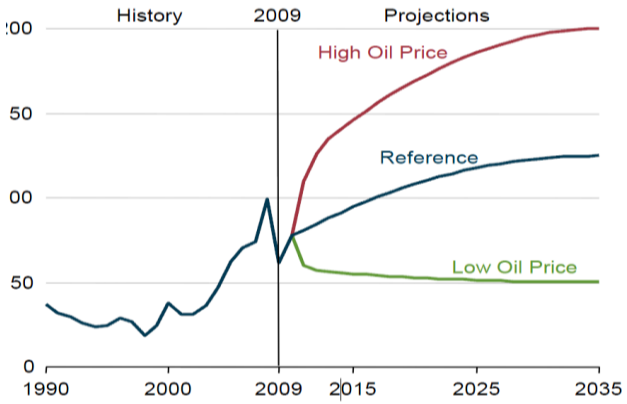
Energy Game Changers for Assured Energy Advantage

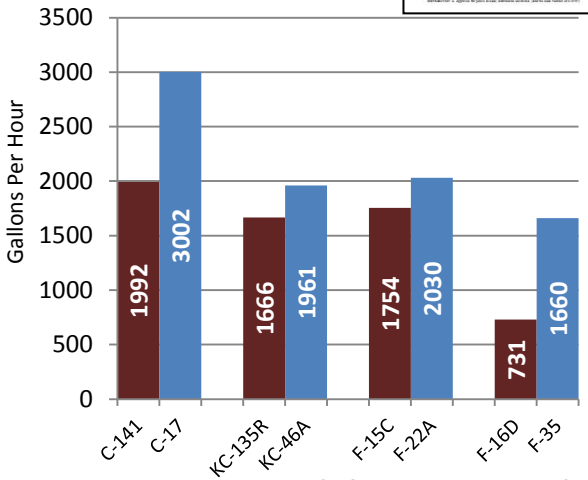




World Energy Consumption (quadrillion Btu)



World Oil Price ($ per barrel)



More Capability, More Fuel

Area	Near (2013-2017)	Mid (2018-2022)	Far (2023-2027)
Propulsion & Aerodynamics	ADVENT (L)	HEETE (L)	
Energy Storage		Nano Materials (L) Carbon-Carbon Nanotubes, Memristers	
	Adaptable Storage/Emerging Battery Technologies (F) Metal Hydrides, Sodium-Air, Electrochemical Flow Capacitor		
	Superconducting Magnetic Energy Storage (W)		
Directed Energy		Directed Energy Power Beaming (L)	
		Directed Energy Kinetic Weapon Alternative (L)	
Energy Harvesting		Energy Harvesting for Small RPAs (L)	
		Inverted Meta-Morphic Space Photovoltaic Arrays (L)	
	Thermoelectric/Pyroelectric Material (F)		
Modeling & Simulation	Systems of Systems M&S (L)		

Greatly Reduced Mass Flow via Lean Logistics

Assets Needed to Close the TPFDD to put JSTARS Package in Theater

- 1 JSTARS; 12 hour mission per day – 1 day
  - 227 support personnel and 4 C-17's of cargo
- When operational:
  - Hotel load of support personnel ~ 20 gal/day/person
  - Typical fuel burn per day JSTARS ~900 gal/hr
- 227 personnel x 20 gal/day = 4540 gallons
- 12 hour mission x 900 gal/hr = 10,800 gallons
- Total gallons = 15, 340 gallons x $4/gal = $61,340/day/JSTARS
- $1.84M/month for 1 JSTARS (fuel cost only)

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AFRL

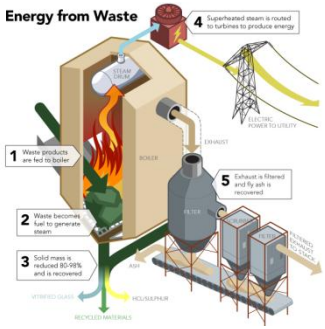
Automation:

www.youtube.com/watch?v=6KRjuuEVEZs

www.youtube.com/watch?v=qxD9Uyz4e9o

On-site manufacture & production:

http://www.youtube.com/watch?v=VhWugjxpueg



www.youtube.com/watch?v=l4G-9uwuKnc&playnext=1&list=PLFAA64E5743637008&feature=results_main

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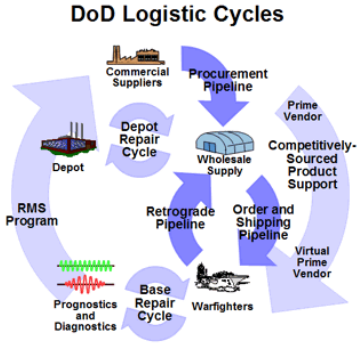


Efficiency:

Transportation Autonomy

Global Shipping at Brisbane Terminal, AU

PATRICK

AUSTRALIA'S LEADING SHIPPING, TRANSPORT, TRADE AND LOGISTICS NEWSPAPER

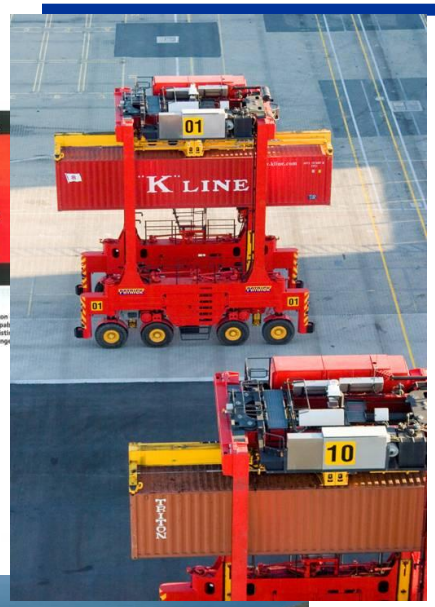
Lloyd's List DCN Special report

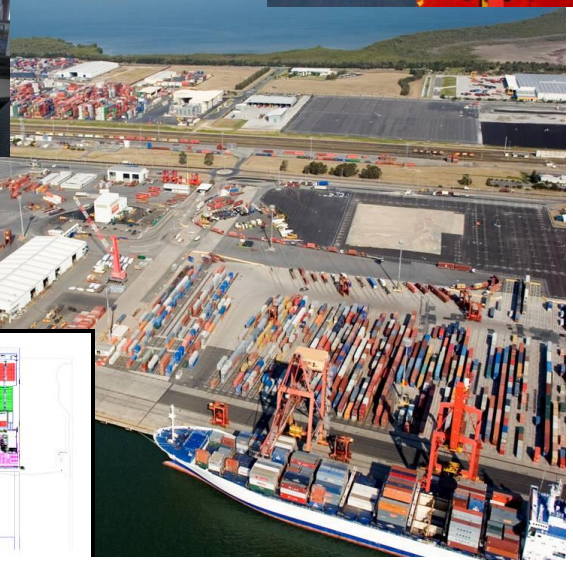
A TERMINAL FOR THE 21ST CENTURY

SUPPLEMENT TO THURSDAY, DECEMBER 1, 2005 /$5

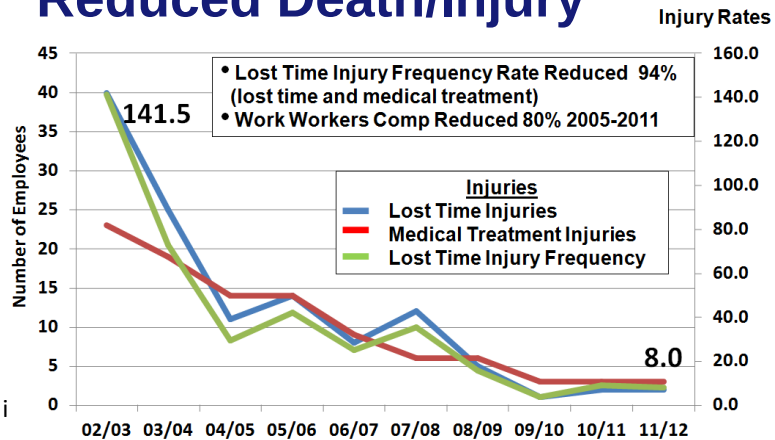
March of the machines

Patrick Corp puts its revolutionary free-ranging robotic technology into full operation at its Fisherman Islands terminal – and creates global interest, reports DAVID WORWOOD





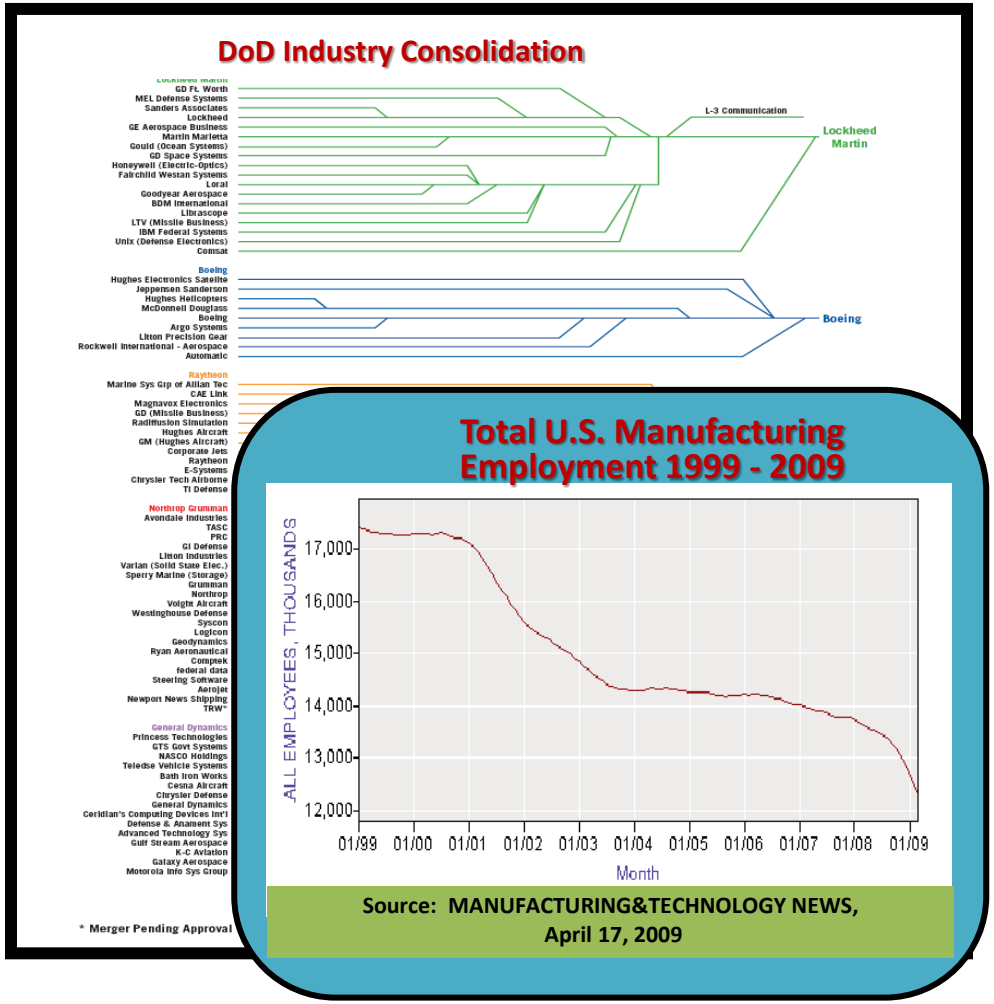
- -27% Labor, -40% Fuel
  - '98: 120k lifts,122 perms, 3 cranes, 500K TEU
  - '12: 320k lifts, 83 perms, 5 cranes, 800K TEU
- Increased Precision (MM radar, 2cm)
- +66% Speed; -70% Maintenance
- Improved Cost, Use of Capital
  - Labor to revenue down 50% to 21%
  - +10% to automate, 1.5 -2yr payback
- Reduced Death/Injury



See video at: tinyurl.com/brisbane-port-autonomy

blic release; distribution i

Manufacturing and Materials Trends



Declining

- Domestic availability of critical raw materials
- US Intellectual dominance
- Manufacturing and industrial base
- Dominance of DoD M&P needs
- STEM resources
- Domestic engineering talent
- Development of major weapon systems
- Experience-base of aging workforce
- Capability/value of current technologies

Increasing

- Non-traditional battlespaces
- Rogue access to manufacturing capability
- Restrictions & Regulations (Environmental+)

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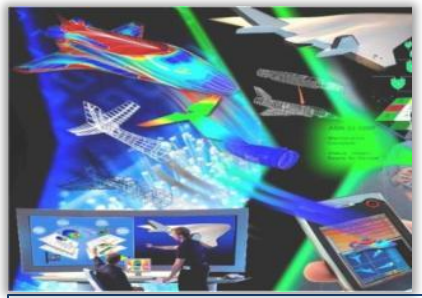
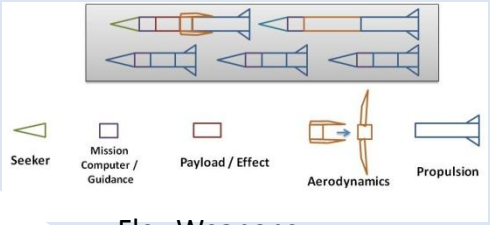
Agile Manufacturing for Rapid & Affordable Fielding

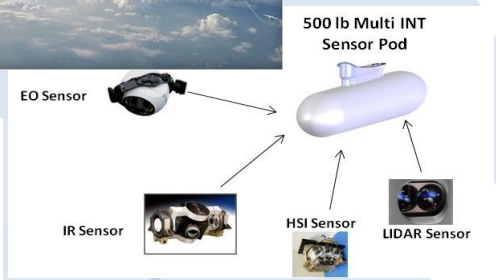
Affordable Capability…… New Systems /sub-systems



Networked Collaborative Design: 60% less time

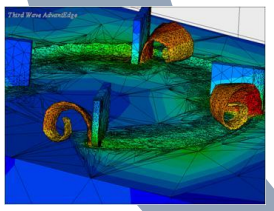


Flex Weapons



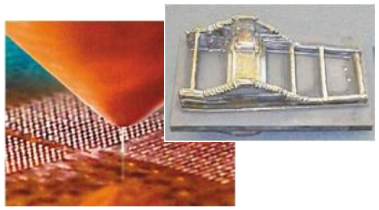
Open Architecture ISR Pod

From S&T to the Field: Faster @ Less Cost



Model-Based/ Virtual Mfg: 50% less time

4. Add. Manuf



Direct Digital & Additive Mfg: Small lot production

Auto/Digital Inspection: 20% less time

Automated Assembly: 30% less time

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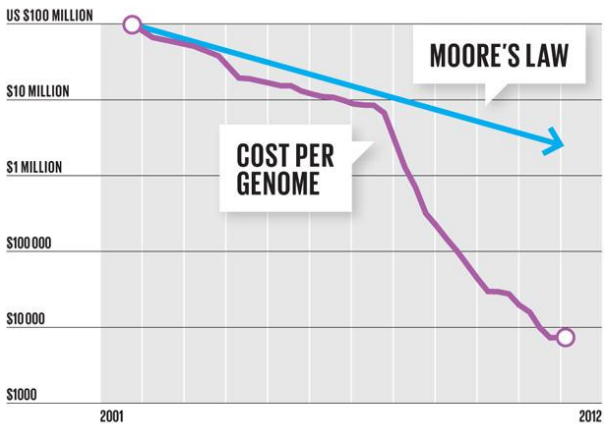
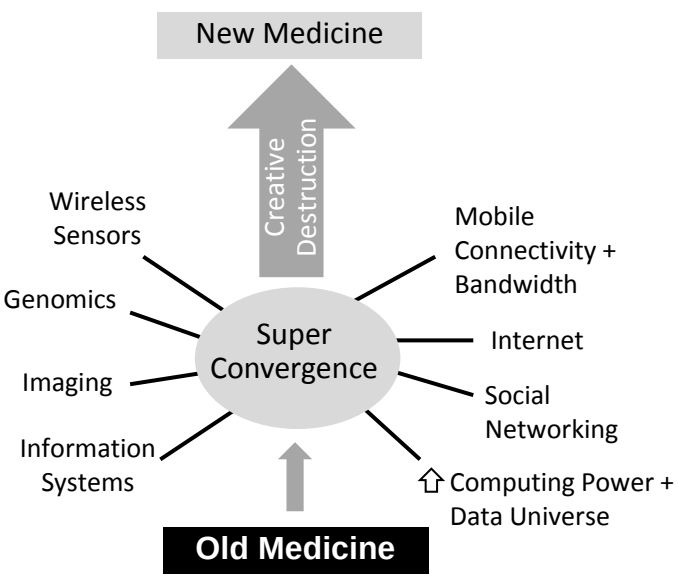
Personalized Medicine/Performance



Source for Data: National Human Genome Research Institute. The big drop, beginning in 2008, is due to the proliferation of next-gen sequencing machines.[8]



Source: Eric Topol; The Creative Destruction of Medicine. Super convergence of global trends that is enabling Personalized Medicine.[4]

- **Increased Precision**

Diagnostic accuracy

- 1300 Genetic tests for ~2500 conditions, new tests emerging monthly

Patient-specific treatments

- '06: 13 vs '11: 72 (5.5x) prominent personalized products

Reduce trial-and-error prescribing

- Current: Yearly, 6.7% patients experience serious adverse drug reactions; Future: PM can decrease this

- **Increased Efficiency**

Rapid genomics: '01=13yrs, '12=24 hrs (Decade to day)

Growth of Electronic Medical Records -

for shared data & evidence-based medicine: US physicians w/EMRs '01=18.2%, '10=50.7%

Reaching patient crowds via Social Media -

@Novartis – 20K followers; @pfizer_news – 24K followers, @JNJComm – 13K followers

- **Decreased Cost**

Affordable genomics '01=$2.7B, '12=$5K

Success in prevention/successful treatment of chronic disease is TBD, but $ savings could be revolutionary

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Enabling Technologies

Area	Near (FY13-17)	Mid (FY18-22)	Far (FY23-27)
Materials sciences	Nanomat'ls and devices (F) Flexible electronics (F) Concept carbon devices (F) Metamaterial antennas etc (L/F) Photonic/plasmonic and quantum concept devices (L/F)	Molecular-engineered mat'ls and devices (F) New carbon electronics (F) Metamaterial devices (L/F) Photonic/plasmonic and quantum nanodevices (L/F)	Convergent nano-bio devices (F) Ubiquitous carbon electronics (F) Fully integrated metamaterial devices (L/F) Integrated photonic/plasmonic and quantum nanodevices (L/F)
Biotechnologies	Biomaterial prototypes (L/F) Bioelectronic studies (F) Human-machine interface designs and concepts (L/F)	Biomaterial components (L/F) Bioelectronic devices (F) Human-machine interfaces (L/F) Neuro-electronic devices (F)	Biomaterial systems (L/F) Bioelectronic systems(F) Human-machine interfaces (L/F) Neuro-based electronics (F)
Autonomous and robotic systems and platforms	Human-like communications (F) Trusted, robust systems and teams (L/F) Capable platforms (L)	Systems in adversarial environments (L/F) Real-time communications (L/F) Capable platforms (L)	Self-learning collective performance, with minimal human supervision, in adversarial environments (L)
Knowledge discovery and decision-making tools	Crowdsourcing (F/W) Data collection / transmission algorithms (L/F) Knowledge discovery tools (F)	Crowdsourcing (L) Integration with planning (L) Knowledge discovery from huge data sets (F)	Crowdsourcing (L) Real-time data-to -decisions tools under adversarial conditions (L) Even-more-complex data sets (F)
Forecasting and effects influence	Social datamining tools (F/W) Effects quantification studies (L) Cognitive-effects modeling (L)	Social sensors (W/F) Social movement prediction (F) Suite of influence tools (L)	Confident, probabilistic prediction methods (F) Influence tools integrated into planning (L)

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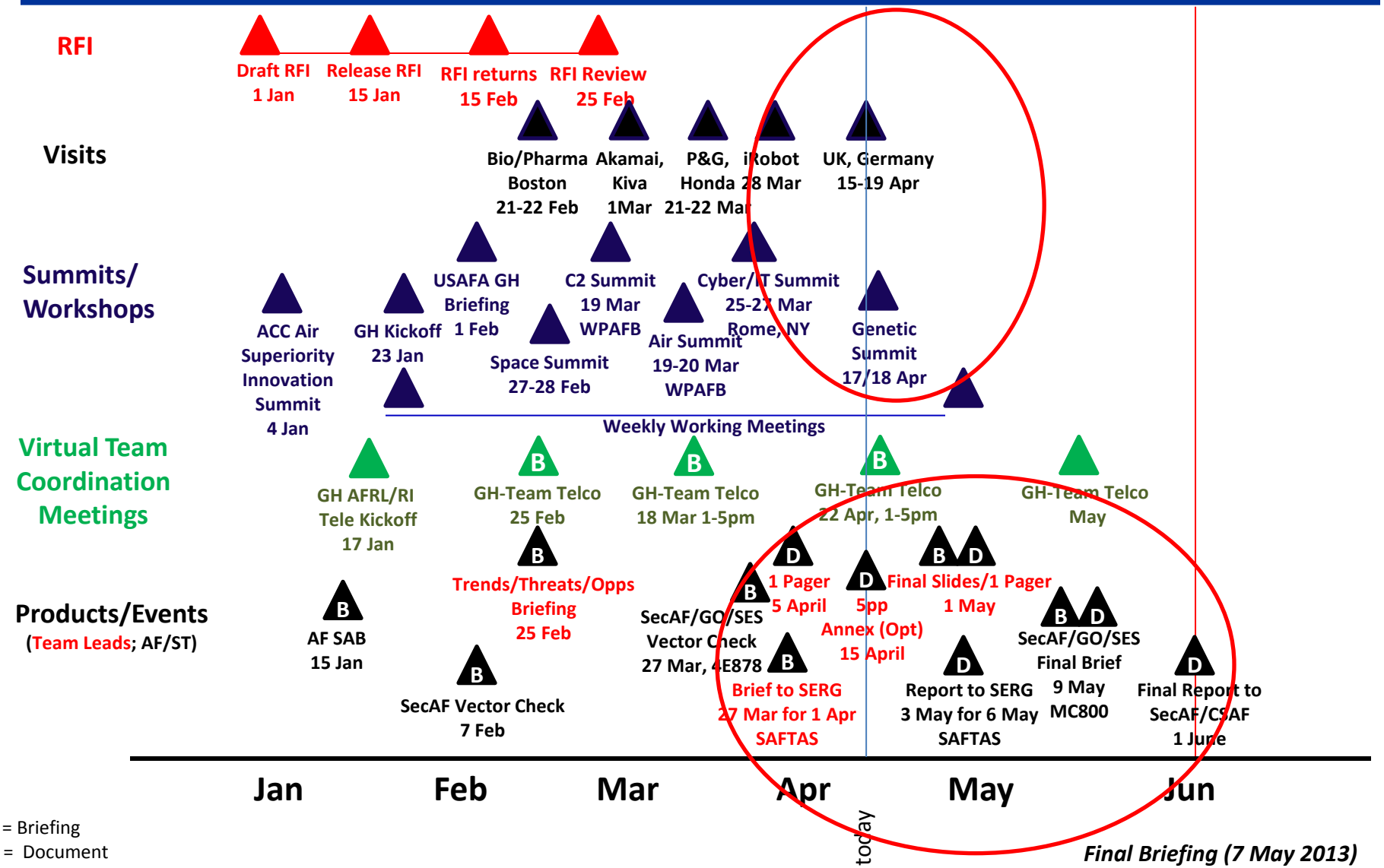
Global Horizons (GH) Next Steps



B = Briefing
D = Document
SERG = Senior External Review Group

Final Briefing (7 May 2013)
Final Report (1 June 2013)

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UNITED STATES AIR FORCE
CHIEF SCIENTIST